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Chrome Tin Red Glazes  
between Seger Cones 2 and 8

Ceramic Engineering

B. S.

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**CHROME TIN RED GLAZES BETWEEN  
SEGER CONES 2 AND 8**

BY

**CHARLES LOUIS WALDUCK**

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**THESIS**

FOR THE

**DEGREE OF BACHELOR OF SCIENCE**

IN

**CERAMIC ENGINEERING**

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**COLLEGE OF LIBERAL ARTS AND SCIENCES**

**UNIVERSITY OF ILLINOIS**

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

*Charles Louis Walduck*

ENTITLED *Chrome Tin Red Glazes*

*Between Seger Cones 2 and 8.*

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF *Bachelor of Science in*

*Ceramic Engineering.*

*B. S. Radcliffe.*

Instructor in Charge

APPROVED: *R. S. Stull*

HEAD OF DEPARTMENT OF *Ceramics*

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## CHROME-TIN RED GLAZES BETWEEN SEGER CONES 2 AND 8.

### INTRODUCTION

The production of chrome-tin reds has been confined in most instances to temperatures between Seger cones 04 and 2. The stoneware manufactures although desirous of producing reds at their temperatures have failed in practically every instance to produce a deep uniform red. It was therefore, decided to investigate the most promising portion of the glaze field within temperature ranges of cones 6 to 8 which is the heat range generally used for maturing stoneware, and develop if possible a good commercial color. Owing to some interesting developments it was later decided to include glazes maturing at lower temperatures. The results obtained were very gratifying but the writer realizes that he has only made a start in the investigation and that further work along similar lines would in all probability bring out many interesting and valuable facts.

A brief review of the published articles on chrome tin colors revealed the following points:

(1) Source of chromium best suited for the production of the chrome tin color: Seger<sup>1</sup> and Carter<sup>2</sup> used potassium dichromate ( $K_2Cr_2O_7$ ) and Hull<sup>3</sup> used chromic acid ( $CrO_3$ ). Purdy<sup>4</sup>

.....  
1. T.A.C.S. Vol.IV. p.231  
2. Ibid, Vol. V. p. 242

3. T.A.C.S. Vol.IV, p. 233.  
4. Ibid, Vol. XI, p. 228.





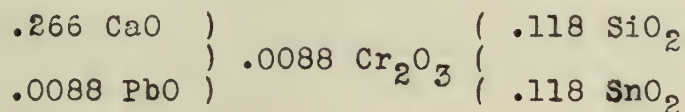
(from whose work the stain composition used in the following work was selected) used various compounds of chromium and stated that different results are obtained with different chromium compounds.

(2) Influence of calcium on the chrome-tin color:

<sup>1</sup> Seger found that if the lime is decreased, the color tends toward lilac and if excluded toward pink. Hensel<sup>5</sup> found that a reduction of lime weakened the color.

### OUTLINE OF WORK

Thorough investigations were made by Purdy<sup>6</sup> on chrome-tin stains and reported very good reds with composition- 1 SnO<sub>2</sub>- 1 SiO<sub>2</sub>- .075 PbCrO<sub>4</sub> and 2 to 2.5 CaO. Therefore, it was decided to use 2.25 CaO, keeping the other constituents of the stain as above. This stain was used throughout the investigations, an amount of the stain sufficient to introduce .118 equivalents of SnO<sub>2</sub> being added to all glazes. All glazes therefore, contained the same molecular quantities of the components of the stain which is shown by the formula:



The work was designed to determine:

(1) The Alumina- Silica ratio best suited for glazes at stoneware heats (cone 6 to 8).

(2) The effect of different glaze composition on the stain at temperatures corresponding to cones 2, 4 and 8- keeping the alumina and silica constant and varying the boracic .....





acid, lead oxide, calcium carbonate and barium carbonate in the RO.

LIMITATIONS AND CONDITIONS ADOPTED: The limits used by Purdy<sup>7</sup> to produce a red from cone 01 to 3 are:-

(1) The stain shall contain 1 equivalent each of tin oxide ( $\text{SnO}_2$ ) and silica ( $\text{SiO}_2$ )- 2.25 equivalents of calcium oxide and .075 equivalents of chromium oxide.

(2) The chromium shall be derived from lead chromate ( $\text{PbCrO}_4$ ).

(3) The stain shall be calcined to cone 8 and then washed.

(4) Each glaze shall contain .1 equivalent of stain thus introducing .1 equivalent of tin oxide ( $\text{SnO}_2$ ).

Since the volatility of  $\text{Cr}_2\text{O}_3$  increases with increase in temperature, the molecular equivalent of the stain was increased to .118 to suit the higher temperatures employed in this work.

#### PREPARATION OF THE STAIN

The materials used in the stain were weighed according to the following batch weights:

|               |       |      |
|---------------|-------|------|
| Tin oxide     | 622.4 | gms. |
| Flint         | 247.6 | "    |
| Whiting       | 930.0 | "    |
| Lead Chromate | 200.0 | "    |
|               | <hr/> |      |
|               | 2000. | "    |



The batch was screened dry, through a 60 mesh sieve several times and well mixed. The mixture was placed in a fire clay sagger and calcined to cone 8 in 20 hours. A fairly uniform distribution was secured by this heat treatment and factory conditions closely approximated. The stain was then washed and decanted twice and dried. The dry stain is brownish red in color.

## THE GLAZES.

### Group A.

The first group of glazes was made to obtain a glaze which had the most suitable  $Al_2O_3$ - $SiO_2$  ratio for cones 6 to 8 heats. The RO constituents and the stain were kept constant, and the  $Al_2O_3$  and  $SiO_2$  were varied as shown in Fig. 1. This group containing 81 glazes was blended as is shown in table #2. The molecular formulae of the four corner glazes are:

|       |             |   |                 |   |              |
|-------|-------------|---|-----------------|---|--------------|
| $A_1$ | .095 $K_2O$ | ) |                 |   |              |
|       |             | ) | .47 $Al_2O_3$   | ( | 1.44 $SiO_2$ |
|       | .62 $CaO$   | ) |                 | ( |              |
|       |             | ) | .0088 $Cr_2O_3$ | ( | .118 $SnO_2$ |
|       | .198 $BaO$  | ) |                 |   |              |
|       |             | ) |                 |   |              |
|       | .097 $PbO$  | ) |                 |   |              |





# TABLE #1. GROUP-A.

.095 K<sub>2</sub>O  
.62 CaO  
.188 BaO  
.097 PbO

.47 Al<sub>2</sub>O<sub>3</sub> { 1.44 SiO<sub>2</sub>  
.0088 Cr<sub>2</sub>O<sub>3</sub> { .118 SnO<sub>2</sub>

.095 K<sub>2</sub>O  
.62 CaO  
.188 BaO  
.097 PbO

.47 Al<sub>2</sub>O<sub>3</sub> { 3.68 SiO<sub>2</sub>  
.0088 Cr<sub>2</sub>O<sub>3</sub> { .118 SnO<sub>2</sub>

| 1                             | 2                                                    | 3                                                     | 4                                                      | 5                                                      | 6                                                      | 7                                                     | 8                                                    | 9                                    |   |
|-------------------------------|------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------|--------------------------------------|---|
| 8A,<br>1A <sub>g</sub>        | 7A,<br>1A <sub>g</sub>                               | 6A,<br>2A <sub>g</sub>                                | 5A,<br>3A <sub>g</sub>                                 | 4A,<br>4A <sub>g</sub>                                 | 3A,<br>5A <sub>g</sub>                                 | 2A,<br>6A <sub>g</sub>                                | 1A,<br>7A <sub>g</sub>                               | 8A <sub>g</sub>                      | A |
| 7A,<br>1I,<br>1I <sub>g</sub> | 49A,<br>7A <sub>g</sub> ,<br>7I,<br>1I <sub>g</sub>  | 42A,<br>14A <sub>g</sub> ,<br>6I,<br>2I <sub>g</sub>  | 35A,<br>21A <sub>g</sub> ,<br>5I,<br>3I <sub>g</sub>   | 28A,<br>28A <sub>g</sub> ,<br>4I,<br>4I <sub>g</sub>   | 21A,<br>35A <sub>g</sub> ,<br>3I,<br>5I <sub>g</sub>   | 14A,<br>42A <sub>g</sub> ,<br>2I,<br>6I <sub>g</sub>  | 7A,<br>49A <sub>g</sub> ,<br>1I,<br>7I <sub>g</sub>  | 7A <sub>g</sub> ,<br>1I <sub>g</sub> | B |
| 6A,<br>2I,<br>2I <sub>g</sub> | 42A,<br>6A <sub>g</sub> ,<br>14I,<br>2I <sub>g</sub> | 36A,<br>12A <sub>g</sub> ,<br>12I,<br>4I <sub>g</sub> | 30A,<br>18A <sub>g</sub> ,<br>10I,<br>6I <sub>g</sub>  | 24A,<br>24A <sub>g</sub> ,<br>8I,<br>8I <sub>g</sub>   | 18A,<br>30A <sub>g</sub> ,<br>6I,<br>10I <sub>g</sub>  | 12A,<br>36A <sub>g</sub> ,<br>4I,<br>12I <sub>g</sub> | 6A,<br>42A <sub>g</sub> ,<br>2I,<br>14I <sub>g</sub> | 6A <sub>g</sub> ,<br>2I <sub>g</sub> | C |
| 5A,<br>3I,<br>3I <sub>g</sub> | 35A,<br>5A <sub>g</sub> ,<br>21I,<br>3I <sub>g</sub> | 30A,<br>10A <sub>g</sub> ,<br>18I,<br>6I <sub>g</sub> | 25A,<br>15A <sub>g</sub> ,<br>15I,<br>9I <sub>g</sub>  | 20A,<br>20A <sub>g</sub> ,<br>12I,<br>12I <sub>g</sub> | 15A,<br>25A <sub>g</sub> ,<br>9I,<br>15I <sub>g</sub>  | 10A,<br>30A <sub>g</sub> ,<br>6I,<br>18I <sub>g</sub> | 5A,<br>35A <sub>g</sub> ,<br>3I,<br>21I <sub>g</sub> | 5A <sub>g</sub> ,<br>3I <sub>g</sub> | D |
| 4A,<br>4I,<br>4I <sub>g</sub> | 28A,<br>4A <sub>g</sub> ,<br>28I,<br>4I <sub>g</sub> | 24A,<br>8A <sub>g</sub> ,<br>24I,<br>8I <sub>g</sub>  | 20A,<br>12A <sub>g</sub> ,<br>20I,<br>12I <sub>g</sub> | 16A,<br>16A <sub>g</sub> ,<br>16I,<br>16I <sub>g</sub> | 12A,<br>20A <sub>g</sub> ,<br>12I,<br>20I <sub>g</sub> | 8A,<br>24A <sub>g</sub> ,<br>8I,<br>24I <sub>g</sub>  | 4A,<br>28A <sub>g</sub> ,<br>4I,<br>28I <sub>g</sub> | 4A <sub>g</sub> ,<br>4I <sub>g</sub> | E |
| 3A,<br>5I,<br>5I <sub>g</sub> | 21A,<br>3A <sub>g</sub> ,<br>35I,<br>5I <sub>g</sub> | 18A,<br>6A <sub>g</sub> ,<br>30I,<br>10I <sub>g</sub> | 15A,<br>9A <sub>g</sub> ,<br>25I,<br>15I <sub>g</sub>  | 12A,<br>12A <sub>g</sub> ,<br>20I,<br>20I <sub>g</sub> | 9A,<br>15A <sub>g</sub> ,<br>15I,<br>25I <sub>g</sub>  | 6A,<br>18A <sub>g</sub> ,<br>10I,<br>30I <sub>g</sub> | 3A,<br>21A <sub>g</sub> ,<br>5I,<br>35I <sub>g</sub> | 3A <sub>g</sub> ,<br>5I <sub>g</sub> | F |
| 2A,<br>6I,<br>6I <sub>g</sub> | 14A,<br>2A <sub>g</sub> ,<br>42I,<br>6I <sub>g</sub> | 12A,<br>4A <sub>g</sub> ,<br>36I,<br>12I <sub>g</sub> | 10A,<br>6A <sub>g</sub> ,<br>30I,<br>18I <sub>g</sub>  | 8A,<br>8A <sub>g</sub> ,<br>24I,<br>24I <sub>g</sub>   | 6A,<br>10A <sub>g</sub> ,<br>18I,<br>30I <sub>g</sub>  | 4A,<br>12A <sub>g</sub> ,<br>12I,<br>36I <sub>g</sub> | 2A,<br>14A <sub>g</sub> ,<br>6I,<br>42I <sub>g</sub> | 2A <sub>g</sub> ,<br>6I <sub>g</sub> | G |
| 1A,<br>7I,<br>7I <sub>g</sub> | 7A,<br>1A <sub>g</sub> ,<br>49I,<br>7I <sub>g</sub>  | 6A,<br>2A <sub>g</sub> ,<br>42I,<br>14I <sub>g</sub>  | 5A,<br>3A <sub>g</sub> ,<br>35I,<br>21I <sub>g</sub>   | 4A,<br>4A <sub>g</sub> ,<br>28I,<br>28I <sub>g</sub>   | 3A,<br>5A <sub>g</sub> ,<br>21I,<br>35I <sub>g</sub>   | 2A,<br>6A <sub>g</sub> ,<br>14I,<br>42I <sub>g</sub>  | 1A,<br>7A <sub>g</sub> ,<br>7I,<br>49I <sub>g</sub>  | 1A <sub>g</sub> ,<br>7I <sub>g</sub> | H |
| 8I,<br>1I <sub>g</sub>        | 7I,<br>1I <sub>g</sub>                               | 6I,<br>2I <sub>g</sub>                                | 5I,<br>3I <sub>g</sub>                                 | 4I,<br>4I <sub>g</sub>                                 | 3I,<br>5I <sub>g</sub>                                 | 2I,<br>6I <sub>g</sub>                                | 1I,<br>7I <sub>g</sub>                               | 8I <sub>g</sub>                      | I |

.095 K<sub>2</sub>O  
.62 CaO  
.188 BaO  
.097 PbO

.095 Al<sub>2</sub>O<sub>3</sub> { 1.44 SiO<sub>2</sub>  
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.095 K<sub>2</sub>O  
.62 CaO  
.188 BaO  
.097 PbO

.095 Al<sub>2</sub>O<sub>3</sub> { 3.68 SiO<sub>2</sub>  
.0088 Cr<sub>2</sub>O<sub>3</sub> { .118 SnO<sub>2</sub>

Blending Proportions.



TABLE #2. GROUP-A.

M.W.-304.7

M.W-439.5

|   | 1                                                                    | 2                                                                                             | 3                                                                                            | 4                                                                                            | 5                                                                                             | 6                                                                                            | 7                                                                                             | 8                                                                                            | 9                                                                |
|---|----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------|
| A | A <sub>1</sub> -100<br>A <sub>9</sub> -17.5                          | A <sub>1</sub> -82.5<br>A <sub>9</sub> -33                                                    | A <sub>1</sub> -67<br>A <sub>9</sub> -47                                                     | A <sub>1</sub> -53<br>A <sub>9</sub> -59.5                                                   | A <sub>1</sub> -40.5<br>A <sub>9</sub> -71                                                    | A <sub>1</sub> -29<br>A <sub>9</sub> -81.5                                                   | A <sub>1</sub> -18.5<br>A <sub>9</sub> -91.2                                                  | A <sub>1</sub> -8.8<br>A <sub>9</sub> -100                                                   |                                                                  |
| B | A <sub>1</sub> -89.5<br>I <sub>1</sub> -10.5<br>I <sub>9</sub> -1.98 | A <sub>1</sub> -74<br>A <sub>9</sub> -15.5<br>I <sub>1</sub> -8.6<br>I <sub>9</sub> -7.1      | A <sub>1</sub> -136.7<br>A <sub>9</sub> -63.0<br>I <sub>1</sub> -14.5<br>I <sub>9</sub> -7.1 | A <sub>1</sub> -47.5<br>A <sub>9</sub> -41.7<br>I <sub>1</sub> -55.2<br>I <sub>9</sub> -52.7 | A <sub>1</sub> -36.2<br>A <sub>9</sub> -53.2<br>I <sub>1</sub> -4.2<br>I <sub>9</sub> -6.5    | A <sub>1</sub> -25.8<br>A <sub>9</sub> -63.3<br>I <sub>1</sub> -3.0<br>I <sub>9</sub> -7.85  | A <sub>1</sub> -16.6<br>A <sub>9</sub> -72.2<br>I <sub>1</sub> -2.0<br>I <sub>9</sub> -9.15   | A <sub>1</sub> -7.9<br>A <sub>9</sub> -81.0<br>I <sub>1</sub> -9.2<br>I <sub>9</sub> -10.1   | A <sub>9</sub> -87<br>I <sub>9</sub> -11                         |
| C | A <sub>1</sub> -78.5<br>I <sub>1</sub> -21.5<br>I <sub>9</sub> -4.0  | A <sub>1</sub> -64.5<br>A <sub>9</sub> -13.7<br>I <sub>1</sub> -17.6<br>I <sub>9</sub> -7.4   | A <sub>1</sub> -52.4<br>A <sub>9</sub> -25.8<br>I <sub>1</sub> -14.3<br>I <sub>9</sub> -7.4  | A <sub>1</sub> -41.5<br>A <sub>9</sub> -36.5<br>I <sub>1</sub> -11.3<br>I <sub>9</sub> -10.7 | A <sub>1</sub> -31.5<br>A <sub>9</sub> -46.3<br>I <sub>1</sub> -8.65<br>I <sub>9</sub> -13.50 | A <sub>1</sub> -22.6<br>A <sub>9</sub> -55.4<br>I <sub>1</sub> -6.2<br>I <sub>9</sub> -16.1  | A <sub>1</sub> -14.4<br>A <sub>9</sub> -63.0<br>I <sub>1</sub> -3.9<br>I <sub>9</sub> -18.5   | A <sub>1</sub> -6.87<br>A <sub>9</sub> -71.0<br>I <sub>1</sub> -1.86<br>I <sub>9</sub> -20.6 | A <sub>9</sub> -77.5<br>I <sub>9</sub> -22.5                     |
| D | A <sub>1</sub> -68<br>I <sub>1</sub> -32<br>I <sub>9</sub> -6.1      | A <sub>1</sub> -55.2<br>A <sub>9</sub> -11.6<br>I <sub>1</sub> -27.1<br>I <sub>9</sub> -6.1   | A <sub>1</sub> -44.6<br>A <sub>9</sub> -22.0<br>I <sub>1</sub> -22.0<br>I <sub>9</sub> -11.5 | A <sub>1</sub> -35.2<br>A <sub>9</sub> -31.1<br>I <sub>1</sub> -17.4<br>I <sub>9</sub> -16.3 | A <sub>1</sub> -26.7<br>A <sub>9</sub> -39.3<br>I <sub>1</sub> -13.2<br>I <sub>9</sub> -20.8  | A <sub>1</sub> -19.7<br>A <sub>9</sub> -46.7<br>I <sub>1</sub> -9.45<br>I <sub>9</sub> -24.3 | A <sub>1</sub> -12.1<br>A <sub>9</sub> -53.8<br>I <sub>1</sub> -5.98<br>I <sub>9</sub> -28.1  | A <sub>1</sub> -5.9<br>A <sub>9</sub> -60.2<br>I <sub>1</sub> -2.86<br>I <sub>9</sub> -31.2  | A <sub>9</sub> -66<br>I <sub>9</sub> -34                         |
| E | A <sub>1</sub> -54.9<br>I <sub>1</sub> -46.1<br>I <sub>9</sub> -8.2  | A <sub>1</sub> -45.3<br>A <sub>9</sub> -9.42<br>I <sub>1</sub> -37.1<br>I <sub>9</sub> -8.2   | A <sub>1</sub> -36.5<br>A <sub>9</sub> -17.9<br>I <sub>1</sub> -30.0<br>I <sub>9</sub> -15.6 | A <sub>1</sub> -28.7<br>A <sub>9</sub> -25.5<br>I <sub>1</sub> -23.6<br>I <sub>9</sub> -22.3 | A <sub>1</sub> -21.9<br>A <sub>9</sub> -32.2<br>I <sub>1</sub> -17.0<br>I <sub>9</sub> -28.2  | A <sub>1</sub> -15.6<br>A <sub>9</sub> -38.2<br>I <sub>1</sub> -12.8<br>I <sub>9</sub> -33.5 | A <sub>1</sub> -9.95<br>A <sub>9</sub> -43.8<br>I <sub>1</sub> -8.25<br>I <sub>9</sub> -38.2  | A <sub>1</sub> -4.65<br>A <sub>9</sub> -48.8<br>I <sub>1</sub> -3.85<br>I <sub>9</sub> -42.7 | A <sub>9</sub> -53.3<br>I <sub>9</sub> -46.7                     |
| F | A <sub>1</sub> -42.2<br>I <sub>1</sub> -57.8<br>I <sub>9</sub> -10.4 | A <sub>1</sub> -34.4<br>A <sub>9</sub> -7.25<br>I <sub>1</sub> -48.0<br>I <sub>9</sub> -10.4  | A <sub>1</sub> -28.2<br>A <sub>9</sub> -13.8<br>I <sub>1</sub> -38.2<br>I <sub>9</sub> -20.0 | A <sub>1</sub> -22.1<br>A <sub>9</sub> -19.6<br>I <sub>1</sub> -30.1<br>I <sub>9</sub> -28.2 | A <sub>1</sub> -16.8<br>A <sub>9</sub> -24.7<br>I <sub>1</sub> -23.0<br>I <sub>9</sub> -35.5  | A <sub>1</sub> -12.0<br>A <sub>9</sub> -29.1<br>I <sub>1</sub> -16.4<br>I <sub>9</sub> -42.5 | A <sub>1</sub> -7.35<br>A <sub>9</sub> -32.5<br>I <sub>1</sub> -10.45<br>I <sub>9</sub> -48.8 | A <sub>1</sub> -3.63<br>A <sub>9</sub> -37.1<br>I <sub>1</sub> -4.98<br>I <sub>9</sub> -54.3 | A <sub>1</sub> -<br>A <sub>9</sub> -87<br>I <sub>9</sub> -117    |
| G | A <sub>1</sub> -29<br>I <sub>1</sub> -71<br>I <sub>9</sub> -13.17    | A <sub>1</sub> -23.6<br>A <sub>9</sub> -4.93<br>I <sub>1</sub> -58.3<br>I <sub>9</sub> -13.17 | A <sub>1</sub> -19.2<br>A <sub>9</sub> -9.3<br>I <sub>1</sub> -46.8<br>I <sub>9</sub> -24.7  | A <sub>1</sub> -15.4<br>A <sub>9</sub> -13.4<br>I <sub>1</sub> -37.0<br>I <sub>9</sub> -34.8 | A <sub>1</sub> -11.3<br>A <sub>9</sub> -16.6<br>I <sub>1</sub> -28.4<br>I <sub>9</sub> -43.7  | A <sub>1</sub> -8.1<br>A <sub>9</sub> -19.9<br>I <sub>1</sub> -20.0<br>I <sub>9</sub> -52.0  | A <sub>1</sub> -5.1<br>A <sub>9</sub> -22.7<br>I <sub>1</sub> -12.6<br>I <sub>9</sub> -54.5   | A <sub>1</sub> -2.5<br>A <sub>9</sub> -25.2<br>I <sub>1</sub> -6.1<br>I <sub>9</sub> -66.    | A <sub>1</sub> -<br>A <sub>9</sub> -27.7<br>I <sub>9</sub> -72.3 |
| H | A <sub>1</sub> -14.8<br>I <sub>1</sub> -85.2<br>I <sub>9</sub> -15.6 | A <sub>1</sub> -12.1<br>A <sub>9</sub> -2.6<br>I <sub>1</sub> -69.7<br>I <sub>9</sub> -15.6   | A <sub>1</sub> -9.85<br>A <sub>9</sub> -4.8<br>I <sub>1</sub> -56.0<br>I <sub>9</sub> -29.4  | A <sub>1</sub> -7.65<br>A <sub>9</sub> -6.8<br>I <sub>1</sub> -44.5<br>I <sub>9</sub> -41.1  | A <sub>1</sub> -5.7<br>A <sub>9</sub> -8.5<br>I <sub>1</sub> -33.3<br>I <sub>9</sub> -52.5    | A <sub>1</sub> -4.1<br>A <sub>9</sub> -10.2<br>I <sub>1</sub> -23.8<br>I <sub>9</sub> -62.0  | A <sub>1</sub> -2.6<br>A <sub>9</sub> -11.6<br>I <sub>1</sub> -15.3<br>I <sub>9</sub> -70.5   | A <sub>1</sub> -1.25<br>A <sub>9</sub> -12.9<br>I <sub>1</sub> -7.25<br>I <sub>9</sub> -79.0 | A <sub>9</sub> -14.1<br>A <sub>9</sub> -85.9                     |
| I | A <sub>1</sub> -<br>I <sub>1</sub> -100<br>I <sub>9</sub> -38.6      | A <sub>1</sub> -<br>A <sub>9</sub> -81.5<br>I <sub>1</sub> -65.5<br>I <sub>9</sub> -34.5      | A <sub>1</sub> -<br>A <sub>9</sub> -65.5<br>I <sub>1</sub> -34.5                             | I <sub>1</sub> -51.6<br>I <sub>9</sub> -48.4                                                 | I <sub>1</sub> -39<br>I <sub>9</sub> -61                                                      | I <sub>1</sub> -27.8<br>I <sub>9</sub> -72.2                                                 | I <sub>1</sub> -17.5<br>I <sub>9</sub> -82.5                                                  | I <sub>1</sub> -8.35<br>I <sub>9</sub> -91.65                                                | I <sub>9</sub> -100                                              |

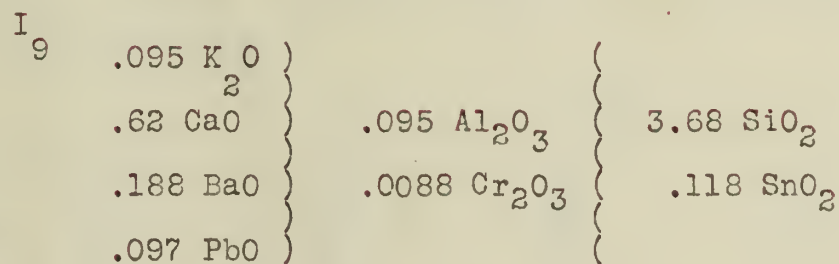
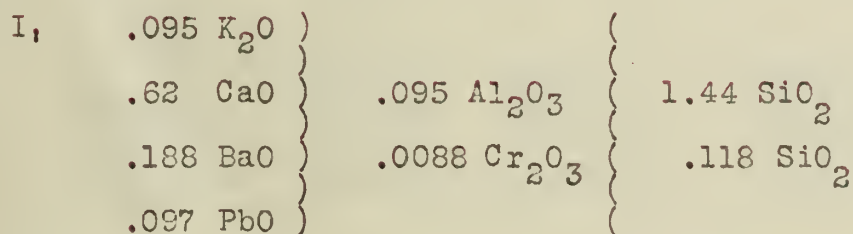
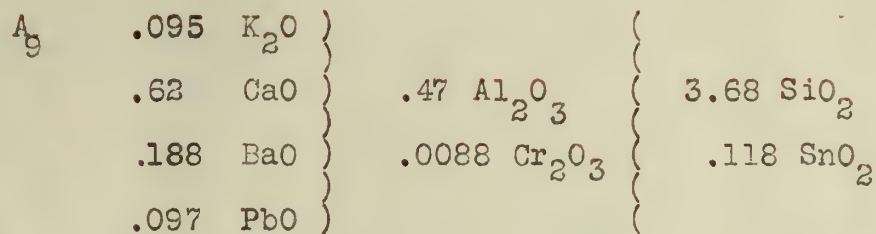
M.W-252.5

M.W-387.5

Blending Weights.









The batch weights of the above are:

|                  | A <sub>1</sub> | A <sub>9</sub> | l <sub>1</sub> | l <sub>9</sub> |
|------------------|----------------|----------------|----------------|----------------|
| Feldspar         | 389.9          | 334.2          | 445.6          | 334.2          |
| Whiting          | 262.5          | 225.0          | 300.0          | 225.0          |
| Barium Carbonate | 276.5          | 237.0          | 316.0          | 237.0          |
| White Lead       | 180.6          | 154.8          | 206.4          | 154.8          |
| Clay             |                |                |                |                |
| (Tenn. #7        | 225.75         | 193.5          |                |                |
| Raw (            |                |                |                |                |
| (N.C.K.          | 135.45         | 116.1          |                |                |
| Calcined N.C.K.  | 361.20         | 309.6          |                |                |
| Flint            |                | 864.0          | 384.0          | 1152.0         |
| Stain            | <u>339.08</u>  | <u>290.64</u>  | <u>387.52</u>  | <u>290.64</u>  |
|                  | 2170.98 g.     | 2724.84 g.     | 2039.52 g.     | 2393.64        |

The glazes were blended so that there were 100 grams of material in each.

The batch weights calculated directly from the molecular formula of the glazes are:

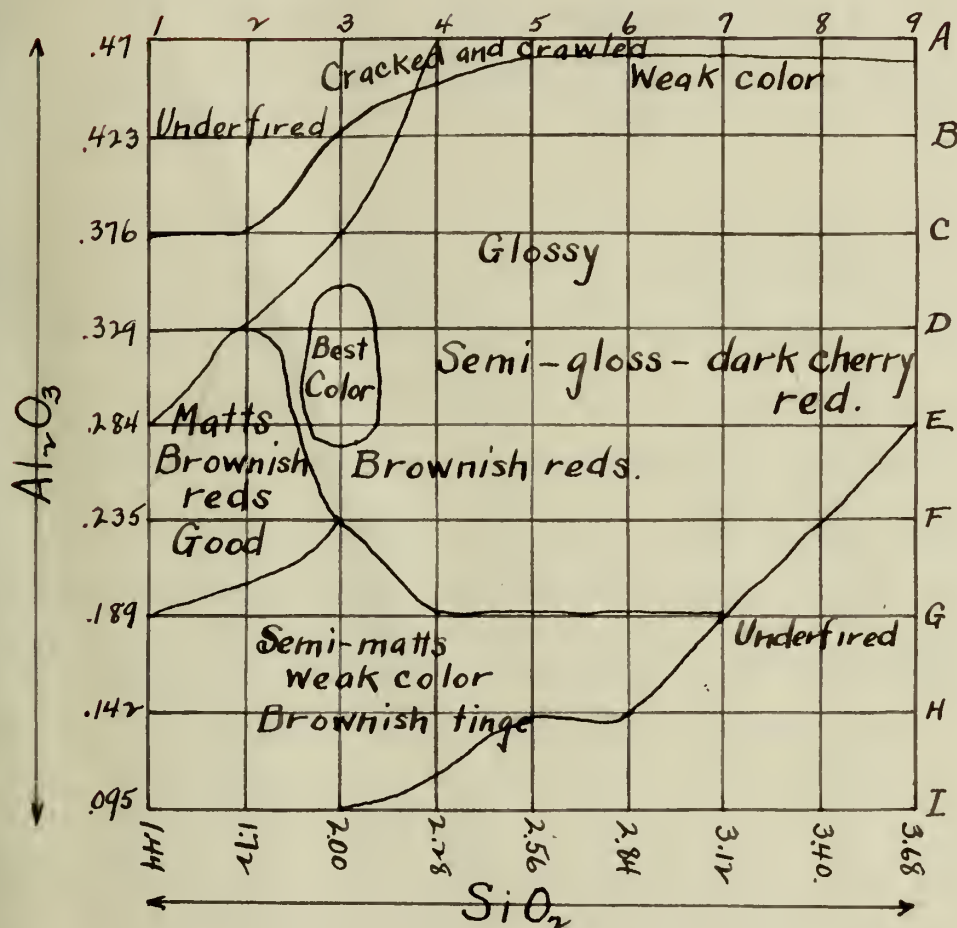
|                  | A <sub>1</sub> | A <sub>9</sub> | l <sub>1</sub> | l <sub>9</sub> |
|------------------|----------------|----------------|----------------|----------------|
| Feldspar         | 53             | 53             | 53             | 53             |
| Whiting          | 62             | 62             | 62             | 62             |
| Barium Carbonate | 37             | 37             | 37             | 37             |
| White Lead       | 25             | 25             | 25             | 25             |
| Clay             | 97             | 97             | --             | --             |
| Flint            | 7.2            | 142            | 52.            | 187            |
| Tin oxide        | 17.8           | 17.8           | 17.8           | 17.8           |
| Chromium oxide   | <u>5.7</u>     | <u>5.7</u>     | <u>5.7</u>     | <u>5.7</u>     |
|                  | 304.7          | 439.7          | 252.5          | 387.5          |





# Fig. I.

$$\left. \begin{array}{l} \text{K}_2\text{O} .095 \\ \text{CaO} .620 \\ \text{BaO} .188 \\ \text{PbO} .097 \end{array} \right\} \begin{array}{l} .095-.47 \text{ Al}_2\text{O}_3 \\ .0088 \text{ Cr}_2\text{O}_3 \end{array} \left\{ \begin{array}{l} 1.44-3.68 \text{ SiO}_2 \\ .118 \text{ SnO}_2 \end{array} \right.$$



Group A.  
E<sub>3</sub> - best glaze.



The four corner glazes were made up and ground in ball mills for two hours, removed, screened, the water factor determined and the blending weights calculated. Two trials of each glaze were made, being applied to U. S. encaustic tile. The trials were burned to cone 7 in an oil fired, down draft test kiln, the period of the burn being 12 hours. Oxidizing conditions were maintained throughout the burn.

RESULTS: The results obtained in this group and shown in Fig. 1 were quite encouraging. They are all red but have a brownish tinge, with the exception of  $E_3$  which is a dark cherry red. It is a semi-glossy glaze, but when applied to a stoneware body and burned to cone 8, it produces a bright glossy glaze that fits well. The glazes containing high clay cracked during drying. The good matts and glossy glazes showed no signs of cracking after dipping, no crazing, crawling or shivering after burning. They fit very well. The best glaze is  $E_3$ .

CONCLUSION- Group A.- In chrome tin red glazes the  $Al_2O_3-SiO_2$  ratio has a decided effect upon the color as is shown in Fig. 1. In this work the best red was obtained with an  $Al_2O_3-SiO_2$  ratio of 1:7.

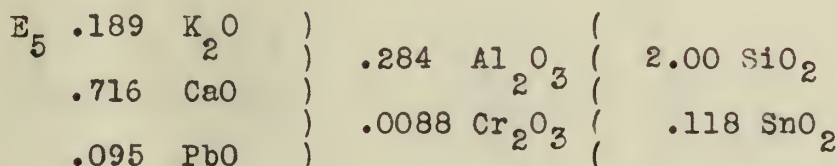
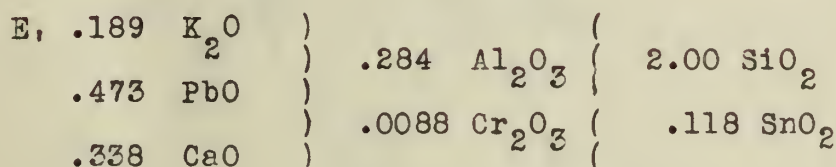
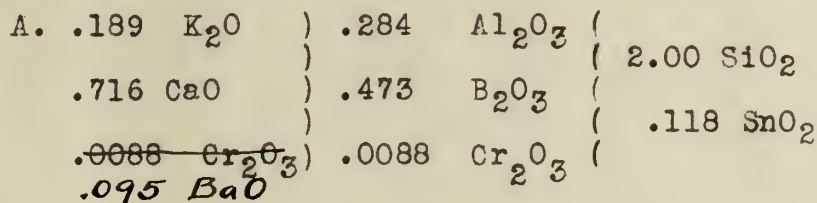
#### Group B

The  $Al_2O_3-SiO_2$  ratio of  $E_3$  was taken as the most suitable to use for further investigation and a second group B consisting <sup>of</sup> 15 glazes was made having this ratio constant and a variable

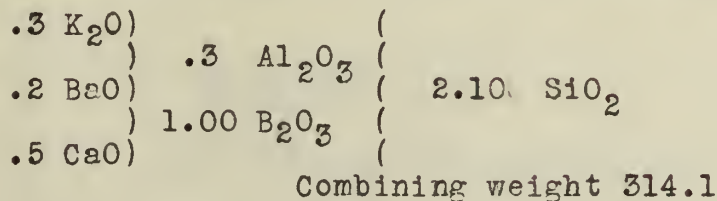




RO and varied boracic acid content. Group B is a triaxial in form having for its corners the three following glazes as shown by their molecular formulae:-



One half of glaze A containing all of the boracic acid was fritted. The molecular formula of the fritt is as follows:

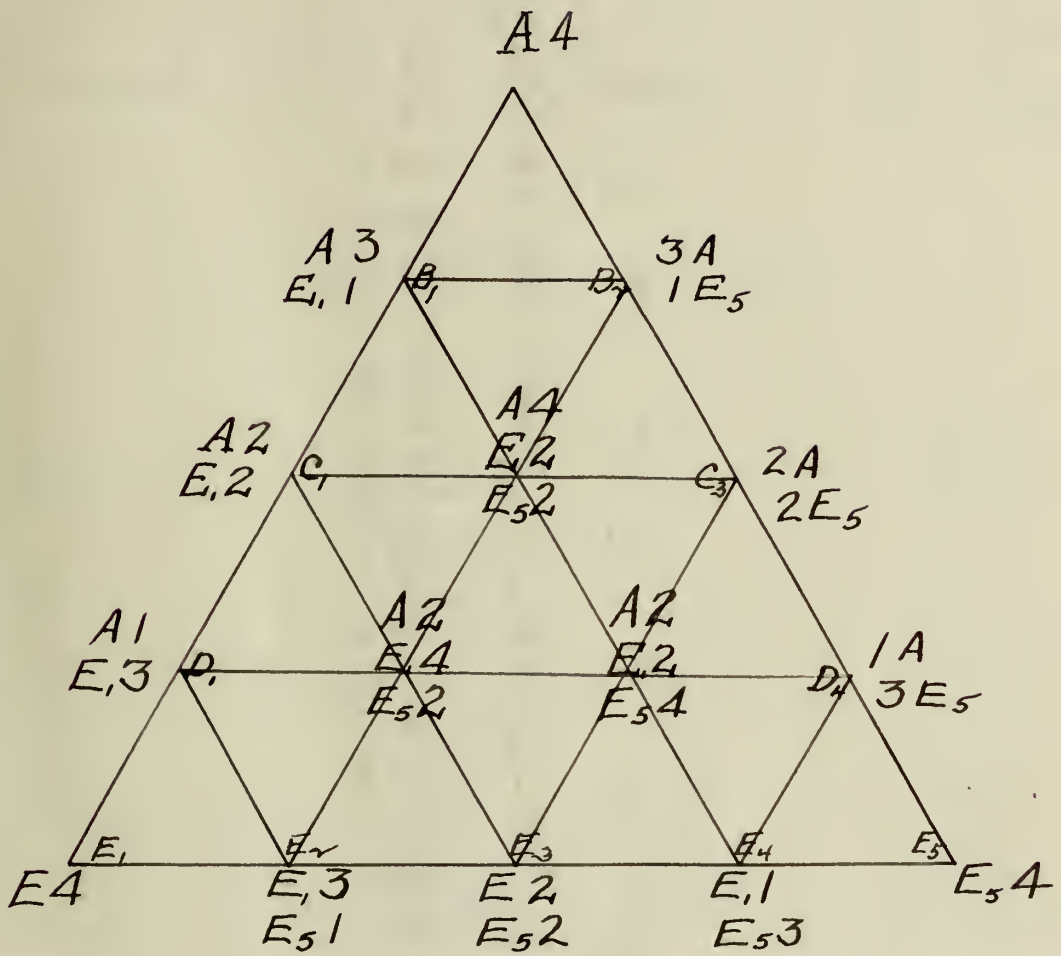


#### Batch Weight

|                   |              |
|-------------------|--------------|
| Potash Feldspar   | 157.5        |
| Berium Carbonate  | 39.4         |
| Calcium Carbonate | 50.0         |
| Flint             | 18.0         |
| Boracic Acid      | <u>124.0</u> |
|                   | 398.9        |



Fig. 2.



GROUP B.  
Blending Proportions.

# Blending Weights.

## Water factors

$$A - 1.68$$

$$E_1 - 1.75$$

$$E_5 - 1.73$$

$$A - 75 \text{ grams.}$$

$$B_1 \begin{cases} A & 54 \\ E_1 & 21 \end{cases} \quad "$$

$$B_2 \begin{cases} A & 56.5 \\ E_5 & 18.5 \end{cases} \quad "$$

$$C_1 \begin{cases} A & 34.7 \\ E_1 & 40.3 \end{cases} \quad "$$

$$C_2 \begin{cases} A & 61.0 \\ E_1 & 37.0 \\ E_5 & 30.0 \end{cases} \quad "$$

$$C_3 \begin{cases} A & 38.4 \\ E_5 & 36.6 \end{cases} \quad "$$

$$D_1 \begin{cases} A & 16.8 \\ E_1 & 58.2 \end{cases} \quad "$$

$$D_2 \begin{cases} A & 17.6 \\ E_1 & 40.7 \\ E_5 & 16.7 \end{cases} \quad "$$

$$D_3 \begin{cases} A & 18.4 \\ E_1 & 21.4 \\ E_5 & 35.2 \end{cases} \quad "$$

$$D_4 \begin{cases} A & 19.4 \\ E_5 & 55.6 \end{cases} \quad "$$

$$E_1 - 75 \text{ grams}$$

$$E_2 \begin{cases} E_1 & 58.8 \\ E_5 & 16.2 \end{cases} \quad "$$

$$E_3 \begin{cases} E_1 & 41.2 \\ E_5 & 33.8 \end{cases} \quad "$$

$$E_4 \begin{cases} E_1 & 21.6 \\ E_5 & 53.4 \end{cases} \quad "$$

$$E_5 - 75 \text{ grams.}$$



The fritt was mixed dry by screening through a 60 mesh screen several times, melted in a down draft fritt furnace and quenched in cold water as it ran out of the bottom of the crucible. It was then ground wet in a ball mill to pass a 100 mesh screen and dried.

The batch weights of group B

|                      | A                 | E,                | E <sub>5</sub>    |
|----------------------|-------------------|-------------------|-------------------|
| White Lead           | <u>          </u> | 128.8             | 25.8              |
| Fritt                | 157.05            | <u>          </u> | <u>          </u> |
| Feldspar             | 29.9              | 111.6             | 111.6             |
| Clay- Tenn. B. C. #7 | 25.8              | 25.8              | 25.8              |
| Flint                | 27.0              | 36.0              | 36.0              |
| Whiting              | 22.5              | 7.5               | 47.5              |
| Stain                | <u>48.4</u>       | <u>48.4</u>       | <u>48.4</u>       |
|                      | 308.69            | 358.14            | 295.14            |

The batches were weighed and ground in ball mills for two hours. The water factor was determined and the glazes blended according to Fig. 2. Three sets of these glazes were dipped on U. S. encaustic tile and burned in 12 hours to cones 8, 4 and 2.

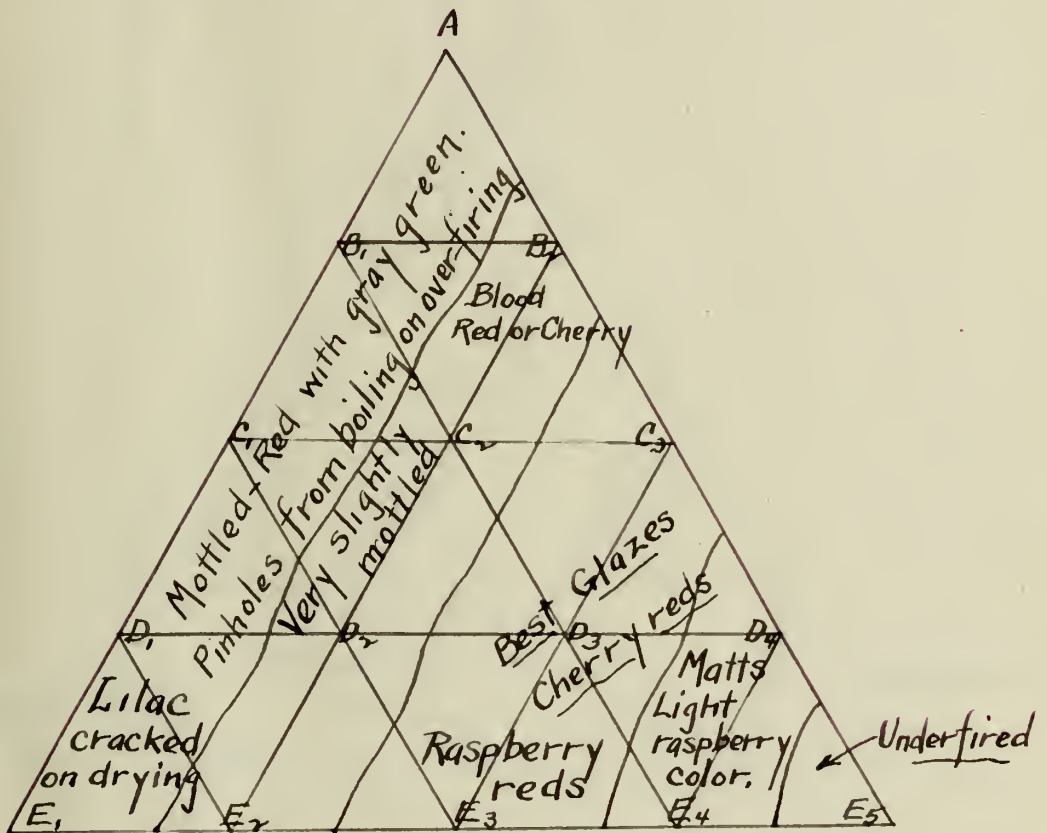


Cone 8 burn.

$D_4$  - best glaze.



Fig. 4.



Group B.

Cone 4 burn.

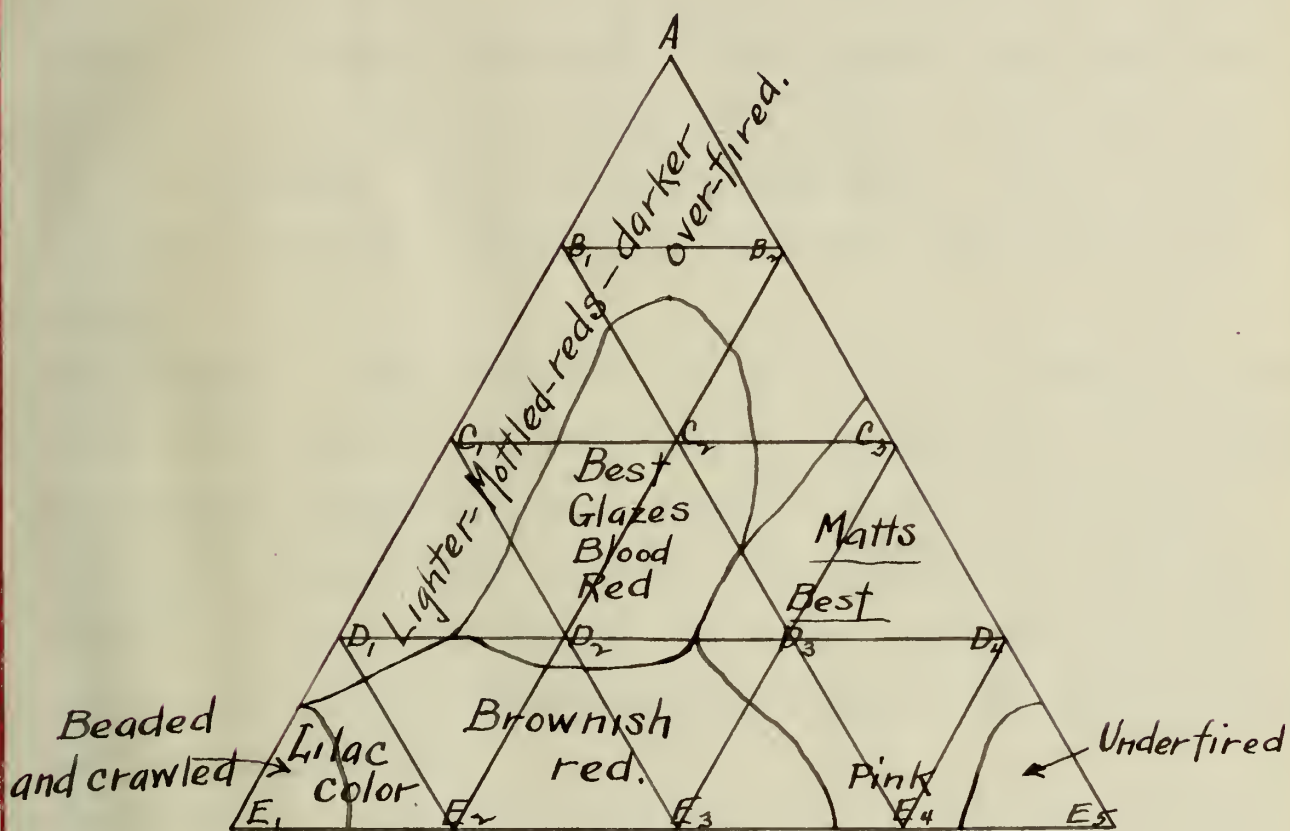
B<sub>2</sub> - best color

D<sub>3</sub> - best glaze.





Fig. 5.



Group B  
Cone 2 burn.  
C<sub>2</sub> - best glaze.



## RESULTS

CONE 8 BURN:- The results are shown in Fig. 3. This burn produced some good colors. As the  $B_2O_3$  and  $Pb_3O_4$  increase, the red changes to a sea-gull green drab. These greens showed small pin-holes due to the formation of gas and probably a second boiling due to overfiring.  $D_4$  is the best glossy glaze. It has a dark raspberry red color. The glaze is opaque and does not craze or crawl.

CONE 4 BURN:- This burn, as is shown in Fig. 4, produced a wider field of red colors. The lower heat did not dissociate the chromet compound, producing greens as much as it did in the cone 8 burn. Nevertheless there was some green present, as in glaze #A, where the red color was mottled with green.  $D_3$  is the best glaze with a color between a raspberry red and cherry red, but  $D_2$  has the best color - blood red.

CONE 2 BURN:- Results are shown in Fig. 5. All of the glazes burned at this temperature are free from green color; those high in boracic acid and lead are slightly over-fired, and with the exception of E, show a mottled effect due to a partial second boiling of the glaze. They probably mature at cone 01 to 1. The mottled effect decreases from A, to E, which shows that the boracic acid glaze is more susceptible to a second boiling than the lead glaze.  $C_2$  is the best glaze. It is opaque and shows no defects.

Glaze  $E_5$  was applied to a piece of biscuit stoneware and burned to cone 8. It retained a good red color, had a good gloss and fitted very well.





# BEST GLAZES AND MOLECULAR FORMULAE

## Group B.

|                               |       |                  |   |       |                                |   |      |                  |  |
|-------------------------------|-------|------------------|---|-------|--------------------------------|---|------|------------------|--|
| Cone 8 Burn<br>D <sub>4</sub> | .189  | K <sub>2</sub> O | ) |       |                                |   |      |                  |  |
|                               |       |                  | ) | .284  | Al <sub>2</sub> O <sub>3</sub> | ( |      |                  |  |
|                               | .716  | CaO              | ) |       |                                |   | 2.00 | SiO <sub>2</sub> |  |
|                               |       |                  | ) | .1183 | B <sub>2</sub> O <sub>3</sub>  | ( |      |                  |  |
|                               | .0713 | PbO              | ) |       |                                |   | .118 | SnO <sub>2</sub> |  |
|                               |       |                  | ) | .0088 | Cr <sub>2</sub> O <sub>3</sub> | ( |      |                  |  |
|                               | .0238 | BaO              | ) |       |                                |   |      |                  |  |

|                               |       |                  |   |       |                                |   |      |                  |  |
|-------------------------------|-------|------------------|---|-------|--------------------------------|---|------|------------------|--|
| Cone 4 Burn<br>D <sub>3</sub> | .189  | K <sub>2</sub> O | ) |       |                                |   |      |                  |  |
|                               |       |                  | ) | .284  | Al <sub>2</sub> O <sub>3</sub> | ( |      |                  |  |
|                               | .6215 | CaO              | ) |       |                                |   | 2.00 | SiO <sub>2</sub> |  |
|                               |       |                  | ) | .1183 | B <sub>2</sub> O <sub>3</sub>  | ( |      |                  |  |
|                               | .1656 | PbO              | ) |       |                                |   | .118 | SnO <sub>2</sub> |  |
|                               |       |                  | ) | .0088 | Cr <sub>2</sub> O <sub>3</sub> | ( |      |                  |  |
|                               | .0238 | BaO              | ) |       |                                |   |      |                  |  |

|                               |       |                  |   |       |                                |   |      |                  |  |
|-------------------------------|-------|------------------|---|-------|--------------------------------|---|------|------------------|--|
| Cone 2 Burn<br>C <sub>2</sub> | .189  | K <sub>2</sub> O | ) |       |                                |   |      |                  |  |
|                               |       |                  | ) | .284  | Al <sub>2</sub> O <sub>3</sub> | ( |      |                  |  |
|                               | .6215 | CaO              | ) |       |                                |   | 2.00 | SiO <sub>2</sub> |  |
|                               |       |                  | ) | .2366 | B <sub>2</sub> O <sub>3</sub>  | ( |      |                  |  |
|                               | .1419 | PbO              | ) |       |                                |   | .118 | SnO <sub>2</sub> |  |
|                               |       |                  | ) | .0088 | Cr <sub>2</sub> O <sub>3</sub> | ( |      |                  |  |
|                               | .0476 | BaO              | ) |       |                                |   |      |                  |  |

## Group B- Conclusions

(1) That good red colors can be made, using chrome-tin stain as a coloring agent, between cones 2 and 8, provided the proper maturing glaze for that temperature is used.

(2) With Al<sub>2</sub>O<sub>3</sub> and SiO<sub>2</sub> constant, an increase of B<sub>2</sub>O<sub>3</sub> changes the color from a raspberry red to a cherry red. In the over-burned glazes containing boracic acid, a second boiling or evolution of gas takes place and at this time dissociation of the chrome-tin stain occurs, with a result that a light green or mottled green mixed with red is developed, depending on the extent of the over-



firing and consequent dissociation.

(3) Glazes in which lead replaces calcium, show color changes from a raspberry red to a lilac when properly matured. In overfired glazes, lead has practically the same effect as boracic acid, namely the production of green or mottled green and red colors.



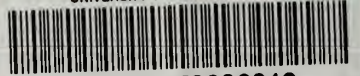








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